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NOTES ON MAP MAKING AND GRAPHIC REPRESENTATION.

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The necessity of a cheap and ready process of systematic map making for purposes of photo-engraving reproduction having been emphasized by recent experience in the preparation of a volume upon the *Races of Europe*, an attempt has been made to invent a number of labor-saving devices by which the old and slow methods of hand work might be obviated. The practicability of these has been demonstrated not only for experts but for educational purposes in the hands of students as well. Practice in graphic representation after methods which are so simple in principle as not to entirely absorb the attention of the student in mere technique, has been found to awaken interest, to vivify dry statistical details, and to stimulate analytical thought; while at the same time developing deftness of hand and accuracy of treatment. No excuse need be offered for a statement of the most simple details in these methods, since experience has shown that the simplest details are oftentimes the most difficult to evolve and to apply.

Before proceeding to the description of various technical processes it will repay us for a moment to consider a few

questions of general principle applicable to all methods of graphic representation. The first of these is the difficulty and danger incident to the use of color schemes. It is a cardinal principle in graphic representation that the visual impression should correspond directly to the facts as related to one another. Any scheme of color, therefore, which is not entirely logical, in a visual sense, is worse than misleading when applied to phenomena which are to be represented in a graduated series. A map in which green, red, yellow, and blue are indiscriminately used to represent different grades of intensity of suicide, for example, is fully as difficult to interpret as the statistical tables which it is intended to elucidate. The only opportunity for representation by means of *unrelated* colors is offered in the case of such phenomena, for example, as the distribution of different nationalities or religions within a country where no relationship in point of fact between the several elements exists. Where applied by Miss Addams in the Hull House Papers to show a hodge-podge of nationalities in the slums of Chicago the proceeding is perfectly scientific. But the occasions appropriate for such use are very seldom. And when unrelated colors are used by Miss Addams again to illustrate a graduated phenomenon, such as the average earnings of families ranging in a scale from $5 to $20 a week, the labor of interpreting the map is immeasurably increased beyond proportion. The evils of the employment of different colors appear perhaps more frequently in home-made wall maps than in the published charts and diagrams of professional statisticians, but the neglect of this cardinal principle is common enough to require mention, at all events, in this place.

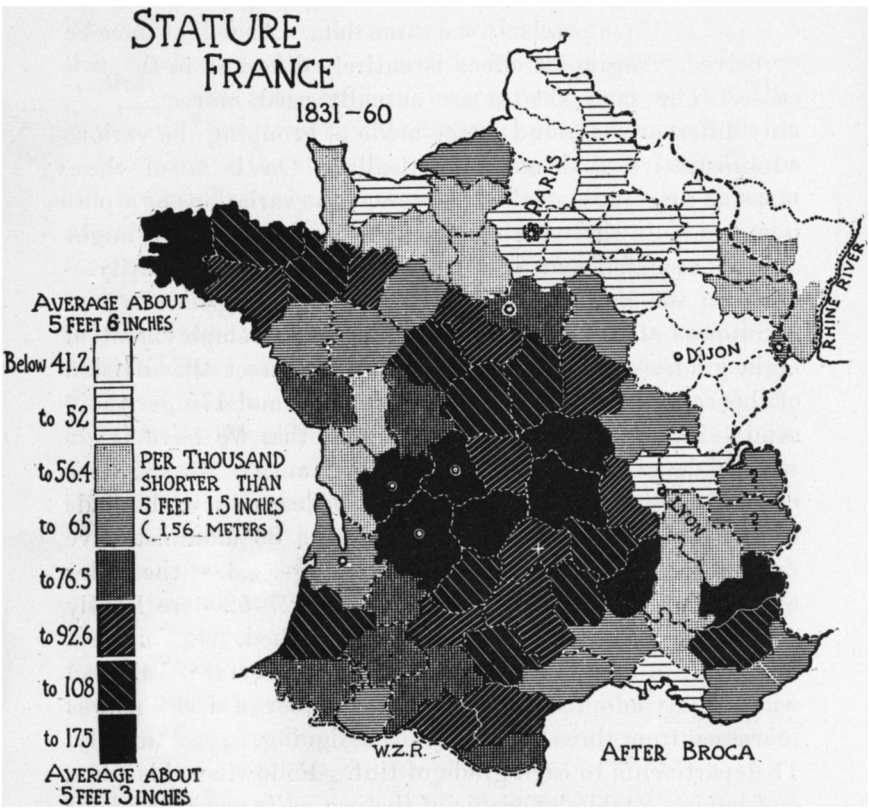
If colors are to be used at all they should either be confined to different intensities of the same color, or else, if the number of shades be too great, two colors, red and blue, for example, may be employed, the deepest tints of each standing at the extremes of the series, and each shading down to an almost white color where the two join at the

medial line. As an example of this mode of representation, see Turquan's map of the density of population in France, in the *Bulletin de l'Institut International de Statistique.*

A second principle in graphic representation is involved in the mere choice of the shading. The seriousness of the possible statistical error involved is manifested by comparison of the two maps of France on following pages. These are constructed from precisely the same data. As will at once be perceived, the graphic effect is entirely different in the two cases. The same shades are actually used, moreover; the only difference is found in the mode of grouping the various administrative divisions statistically. On both of these maps an attempt is made to represent the variations of a phenomenon — in this case it happens to be stature, but it might as well be suicide or any other demographic peculiarity — between the limits of 24 and 175 per 1000, respectively.

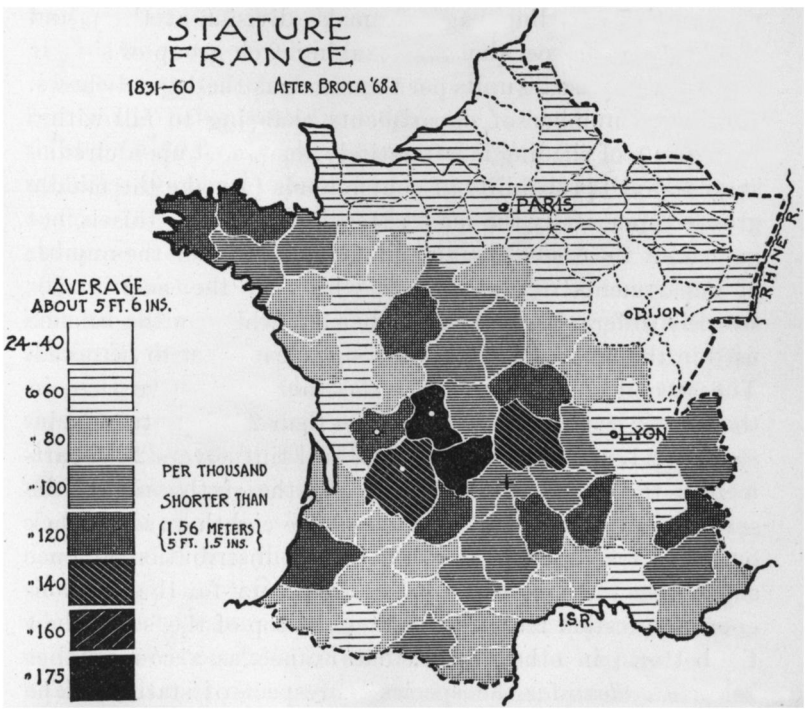
Suppose that we have decided upon the employment of eight grades of shading. How shall we effect the division of this range of 151 units, *viz.*, between 24 and 175 per thousand — into its eight grades, supposing that we have to do with 86 departments, as in the case of France? Broca, in his original map of stature used three shades only, each grade of tint being applied to one-third of the 86 administrative divisions. Thus, departments numbering 1–26 in the order of tallness of stature were made white; 27–52 were lightly shaded; and 53–86 were closely cross-hatched. In our first map, on the next page, precisely the same statistical plan was roughly adopted; although the number of divisions was increased from three to eight, thus assigning, approximately, 11 departments to each grade of tint. Following this plan, and having a table before us of the *pro mille* proportions for 86 departments, we designate the first 11 in order at the top by our lightest tint. It happens that the division falls, as the legend shows, at 41.2 per thousand. The first tint, therefore, has a range of 17.2 units, that is to say, from 24, the lowest proportion of defective statures, to 41.2 per thousand.

The second group of 11 departments similarly shaded carries us to a frequency of 52 per thousand, giving a range of 10.8 under the same tint. The third group of 11 departments happens to lie between the limits of 52 and 56.4 *pro mille* with a range of less than half the preceding one, or only 4.4. Thereafter the range of each similarly shaded group of 11



departments rises, as 8.6, 11.5, 16.1, and 15.4, respectively, until the last one reaches the maximum range from 108 to 175 per thousand. Nine departments, in other words, on this first map, as we see, are colored black, representing a range of 67 units per thousand (108 to 175).

The fallacy in this process is too apparent perhaps to need explanation; nevertheless it is surprising, in view of the simple principle involved, to see how commonly the error is committed, especially in the sciences which make but occasional appeal to statistical representation. The effect is at once obvious. The extremes of the statistical series, those departments within which the phenomena are respectively



most and least frequent, are shaded into undue geographical prominence and extent. Thus, for example, on this first map the areas of very short stature, characterized by great frequency of defectives, are much wider in their extension as visually represented than they are in fact. In other words, the restricted locality in which physical degeneracy really

culminates is generalized over a far larger area than it ought to be. The obvious fact that the phenomenon tends to aggregate about the mean or center is quite obscured at the same time.

The proper procedure in this case would seem to be not to divide the departments into shaded groups equal in number, but rather to divide the range of the phenomenon itself from least to maximum into equal groups. Thus, as on our second map on the preceding page, we make division at the round numbers of units per thousand, making each group of similar shading comprise 20 units per thousand, as the legend shows. The actual number of departments chancing to fall within each group of shading is left entirely dependent upon circumstances. All probability of course tends to make the middle groups numerically the most extensive, although this is not invariably the case. As it stands in this instance the number of departments represented as white on the map is 10; scarcely different from the number left white on the scheme used in the first map. This is a significant fact to be noted. The second shade, however, is far more extensive than in the former case, comprising no less than 26 departments instead of 11, as before; while the third tint covers 21 departments; the fourth, 15; the fifth, 10; the sixth, only 2; the seventh, not represented at all; and the eighth or solid black one covers only 2 departments. This distribution at once shows that the center of greatest frequency for the phenomenon in question really lies nearer the top of the scale than the bottom; in other words, that France, as a country, lies below the mean for the species in respect of stature. The commonest proportions, judged by that geographical distribution, lie in the vicinity of 60 defective individuals per thousand. This the map shows at once by its general light tone and shading, as it should. According to the first map, on the other hand, this center of distribution — or shall we say frequency — appears to be considerably higher at the middle grades of tint between black and white, namely, about 65 to

76 per thousand. This is obviously a falsification, to the eye, of the statistical fact, as a moment's consideration suffices to show.

The third point of principle to which we wish to direct attention is concerned with the lettering of the legend. This involves an error which is more frequent perhaps than either of the other two that we have mentioned. It arises more often from carelessness of the operator than from real confusion of thought. It is a fault which appears upon both of the two maps which have been reproduced herewith.

Suppose that the legend upon a map reads as follows: The first shade being labled "1–10," the second "10–20," the third "20–30," etc. At what point does the real division statistically occur? Is No. 10.0 included in the first group, or does this alone comprise Nos. 1–9.99, inclusive? One is always at a loss to interpret a scheme of this kind, especially when division occurs other than at a round number; and it is in all cases probably far better to avoid the possibility of ambiguity by the employment of some other method. The several groups may be lettered "1–9 inclusive," "10–19 inclusive," etc., or else, what is probably better, they should be labelled "1–9.99," "10–19.99," etc. In this last case there is no possibility of misunderstanding, and the mind of the observer is immediately set at rest. When this is not done, nine times in ten the assumption is perhaps justified that this is what the statistics meant; but cases are no means rare where the opposite meaning was intended, especially whenever the division falls, as we have said, not on the round numbers but at some odd figures, as one, our first map of France, for example.

Having treated of these few points of principle we may now proceed to consider matters of technique. The first method we will call that of "pasting tints." The materials necessary are a piece of stiff cardboard large enough for the map; tracing cloth or paper, carbon paper for transferring tracings; and India ink, or what is even better, Higgins'

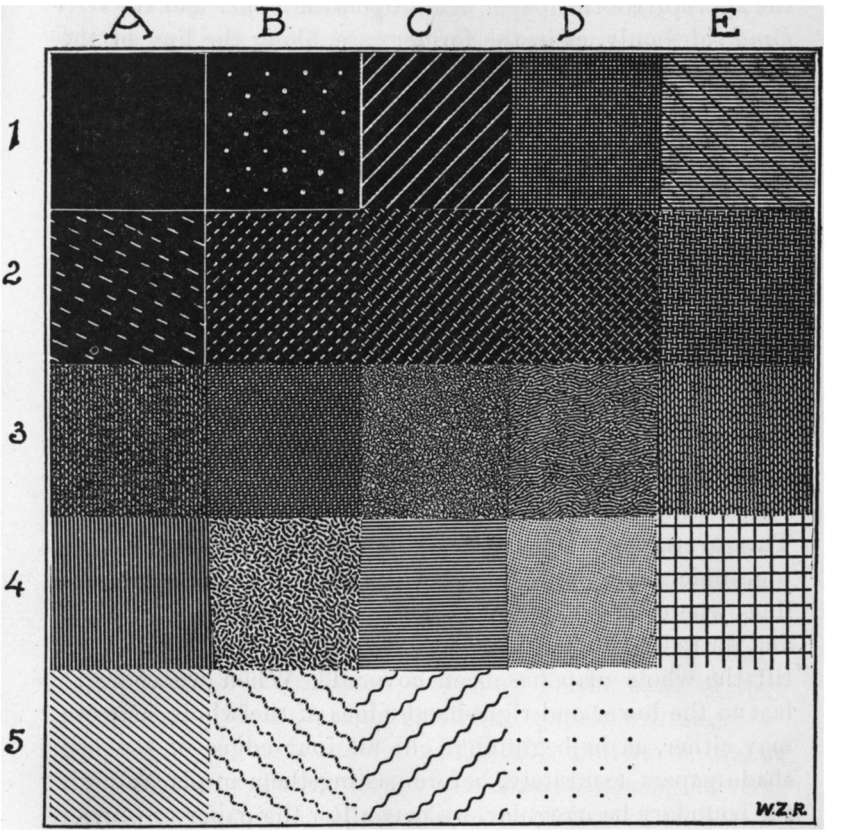
prepared drawing inks; sharp scissors, a keen pen knife, a bottle of China white water-color paint, some flour paste, or preferably Higgins' Photo-mounter, etc.; and finally a set of black and white printed tint papers, such as, for example, those illustrated by sample in the diagram on the next page.

Having decided upon the grades of tint which we will employ, in accordance with the above mentioned principles, the following steps should be taken: —

(1) Make an accurate tracing of the outlines of the map to be constructed, and transfer it by means of the carbon paper to the stiff cardboard. The reason for the employment of cardboard is, of course, to prevent the curling and warping of the paper in the process of pasting. It will be found advantageous at this stage of the proceeding to paste the tracing along one edge of the cardboard so that it will accurately register or overlie the map as transferred upon the pasteboard. Then it may be folded back out of the way, except when needed for purposes of location. If a sufficient number of maps are to be made, printed outlines may in many cases be procured of publishers. We have, for instance, had such outlines prepared for the State of Massachusetts by counties and towns, the city of Boston by wards, etc.

(2) Beginning at one corner of our proposed map, let us say the upper left hand (A1 upon the diagram on next page), make a tracing upon the prepared tint paper by means of carbon paper of the department, county, township, ward or other administrative division to be shaded; and cut out the paper accurately upon its *upper* and *left-hand* sides only, along the lines thus traced. If these boundaries be straight and simple, as, for example, in the north-west corner of Massachusetts, they may perhaps, as we have said, be best cut out along the traced line. If, however, the map be for photographic reproduction, or if the outside boundary on these sides be irregular, such as a coast line, it will be found simpler to let the piece of tint paper extend out indefinitely, say one-quarter of an inch, beyond the boundary of the map

all along. Then having pasted the paper in its proper place upon the cardboard, as indicated by means of the tracing which may be folded down over the cardboard for the purpose of locating the pasting slip, paint over with China white all of the tinted paper which projects beyond the boundary,



inking in the actual edge of the map of course to give a finished effect. It will be noticed that no attempt has been thus far made to cut the *lower* and *right-hand* edges of this first piece of tinted paper accurately along these boundary

lines of the department, the paper having been merely left to project well over into the adjoining areas. (B1, B2, A2, on our diagram on the preceding page.)

(3) Make a tracing of the outlines of the area A2 which we will suppose to represent the adjoining state, county, town, or ward, as the case may be; and cut out a piece of the appropriate tint paper again upon the *upper* and the *left-hand* sides only, as in the former case, along the line of the tracing. Here, again, the *lower* and the *right-hand* sides are left to project indefinitely, well over beyond the boundary of this particular area. Paste this second tint paper in place; first, along its upper and left-hand sides, locating it by means of the general tracing of the whole map which, as we have already said, has been pasted to the cardboard by one edge and temporarily folded back out of the way. This will enable the tint paper to be brought accurately into register in its appropriate place. The area B1 is then similarly treated; then B2, A3, and so on; each tint paper overlapping its neighbor upon two sides only. In other words, we are simply shingling the map like a roof from its upper left-hand corner down and out, thus avoiding the difficult task of exactly fitting respective edges of the pasted papers together. This overlapping of the paper is not apparent on a photographic reproduction, especially since in most cases the lines where the shades overlap will be indicated by a black and dotted boundary, afterward inked in. Thus we proceed till the whole map has been covered. When we come at last to the lower and right-hand edges of the whole map we may either, as in beginning, cut all four edges of the last shade papers accurately, before pasting them in place; or, if the boundary be irregular, we may allow the paper to project beyond, and then paint over the superfluous part up to the boundary line with China white. Wherever covered with the white paint the projecting parts will disappear in a photographic reproduction which only takes note of clear black lines.

At this point a word may be said respecting the process of transfer and tracing by means of carbon paper. It will be found advisable to avoid, so far as possible, all black lines upon the face of the shade papers, as they are likely to smut and are difficult to obliterate. For this reason tracings of the outlines may best be transferred to the tint papers, either by indenting the outline by means of a dull steel stylus, or else the outlines may be transferred in carbon upon the *back* of the tint papers; that is, by laying the carbon paper face up upon the table, upon it place the tint paper the boundary of which is to be cut out and on top of all the tracing. Then by running a pencil or a steel point around the boundary of the tracing the carbon transfer is made upon the back of the tint paper instead of upon its face with far better results in the finished map.

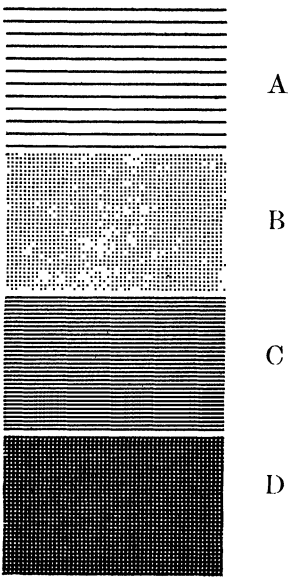
As for the tint papers to be used in this case a primary difficulty of course is to secure a sufficient variety of shades. Intermediate tones are common enough among artists' supplies in various forms, but we have found it necessary to make by hand a number of the darker shades, the varieties at hand being indicated within the diagram on page 9 to which we have referred. These must be adapted for each map, with an eye especially to the degree of reduction which is to be made by the photographer, as well as to the statistical contrasts which are to be sought. It is a well recognized fact that by choosing tints aright almost any desired effect of emphasis can be produced according to the skill of the manipulator. Most of these particular papers will stand a reduction anywhere up to "one-half off"; that is to say, a reduction of area of one-quarter, each dimension being halved. Many of the finer texured ones, however, will give far better effects with a less reduction, say "one-quarter or one-third off."

In the matter of shading it should be noted that the employment of flat colors, or tinting, except for solid black, renders the reproduction very much more expensive than in

those cases where a definite texture, either in black or other color, can be used. Wherever a texture, such as cross-hatching, dots, etc., can be employed, and where the reproduction is to be in black, the process of photo-engraving is possible, and the expense is relatively small. On the other hand, wherever flat tints, washes, or solid colors without texture are employed it is necessary that the reproduction be by lithography or half-tone process, both of which are very much more expensive. For this reason it will be found far more advantageous to employ shades which have a texture such as those illustrated herewith than those of the other sort. Of course in drawing in any case the solid black areas are merely inked in with a brush, using a pure carbon drawing ink of the best sort. Ordinary writing ink is useless, as it gives a most imperfect black, full of faults in a photographic reproduction.

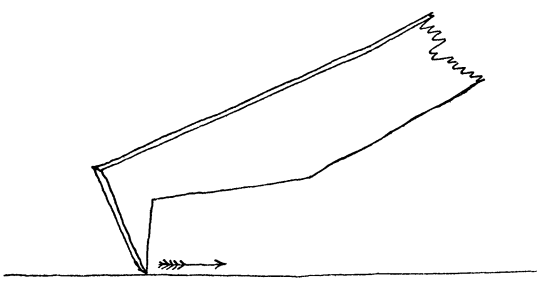
One more process somewhat more specialized deserves mention in conclusion. The credit for the original suggestion to me of this process is due to my artist friend, Mr. Frank B. Masters, who called my attention to the methods used in rapid illustration for newspaper work. Among these processes the best is perhaps the use of so-called Ross stipple-board. This is a paper with a thick clay surface minutely ribbed in one direction with black lines equally spaced at right angles to the ribs. Each black line upon this paper, therefore, runs up and down over a gridiron of ribs. To the eye this irregularity of surface is scarcely noticeable, and photographic processes take no note of them. Thus C upon our specimen diagram on the next page represents the paper as sold by dealers. Upon scratching it lightly with a broad sharp knife, the black lines are obliterated wherever they rise over and cross the ribs upon the paper, while the black remains in the intermediate hollows. By this simple means is produced the tint B. On the other hand, if rubbed with a pencil or greasy carbon the crests of all the ribs upon the paper are blackened throughout their whole length, producing

a series of cross lines at right angles to the original printed ones; thus is D produced. Of course all parts of the paper outside the map boundary are at the outset scratched white, a result easily produced, as the clay surface is intended for the purpose.

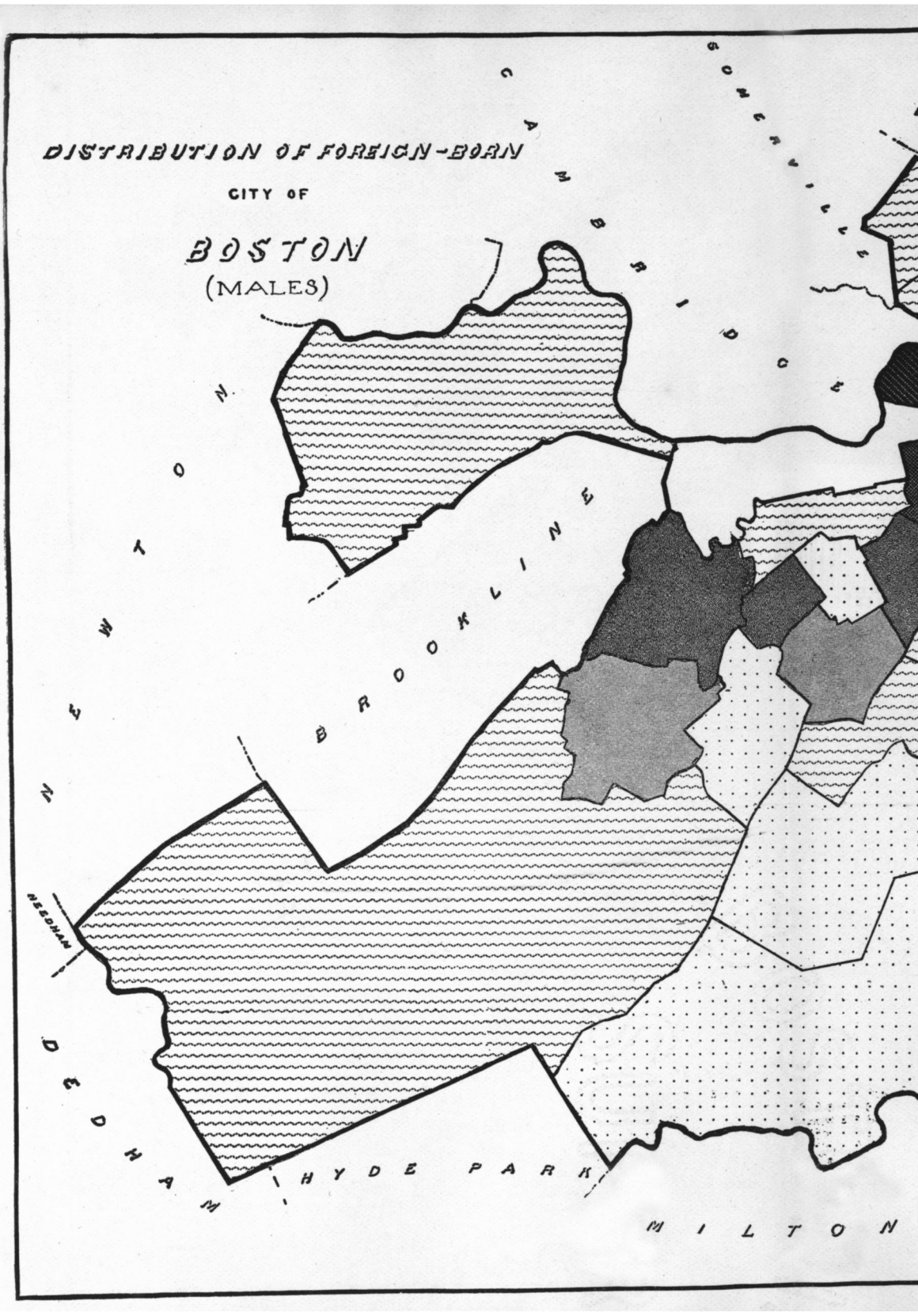


Beside these tints a number can be produced on Ross paper by various manipulations more or less complex and technical. Higgins' prepared or other India ink gives a solid color which may be punctured with white dots as in B1 (p. 9) by the use of a sharpened drill twirled between the fingers. This blackened space can also be scratched white in lines as readily as black lines are drawn with a pen. For this purpose we have devised a tool, shown in the cut on page 14, made from a bit of old saw blade or thin steel, ground to a chisel point. This is used with a ruler just as a pen to produce the effects; for example, shown in Nos. C1, A2 (p. 9). Or the Ross paper before being blacked may be deeply cut with this tool in any way desired and thereafter coated with ink

by brush. Thus the ink lines become deeply indented below the surface of the paper. Then if the whole surface be lightly scratched with a penknife, the tops of the original ribs on the Ross paper come out white, leaving the effect shown, for example, in No. E1 (p. 9). Finally by using the same steel tool, with a point of the right breadth, any desired number of intermediate black lines on the original Ross paper can be removed leaving a few widely separated ones with the effect of light cross-hatching, as in A on page 13. Such are only a few of the results possible. Ingenuity will enable others to be devised to fit the peculiar circumstances; and then of course, best of all, these results may be combined with those of the pasting tints previously described, so that almost any desired number of tints between black



and white may be obtained. All of these latter processes, however, and even the simple use of the Ross paper, presuppose more skill than the average student can acquire in a short time. Experience has shown that the simplest process gives the best results. The appended map, by wards, of the city of Boston represents the work of a first-year student at the Institute of Technology. It required about eight hours to make in the first attempt. This was photo-engraved with a reduction of about "one-half off," at a cost of, approximately, $4.00. Such work is easily within the powers of any student of statistics, and will be found greatly to increase the interest in research. It is merely a legitimate application of those laboratory methods which should receive far more consideration than is usual in many of our educational institutions.


DISTRIBUTION OF FOREIGN-BORN
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(MALES)
CAMBRIDGE
SOMERVILLE
NEWTON
BROOKLINE
NEEDHAM
DEDHAM
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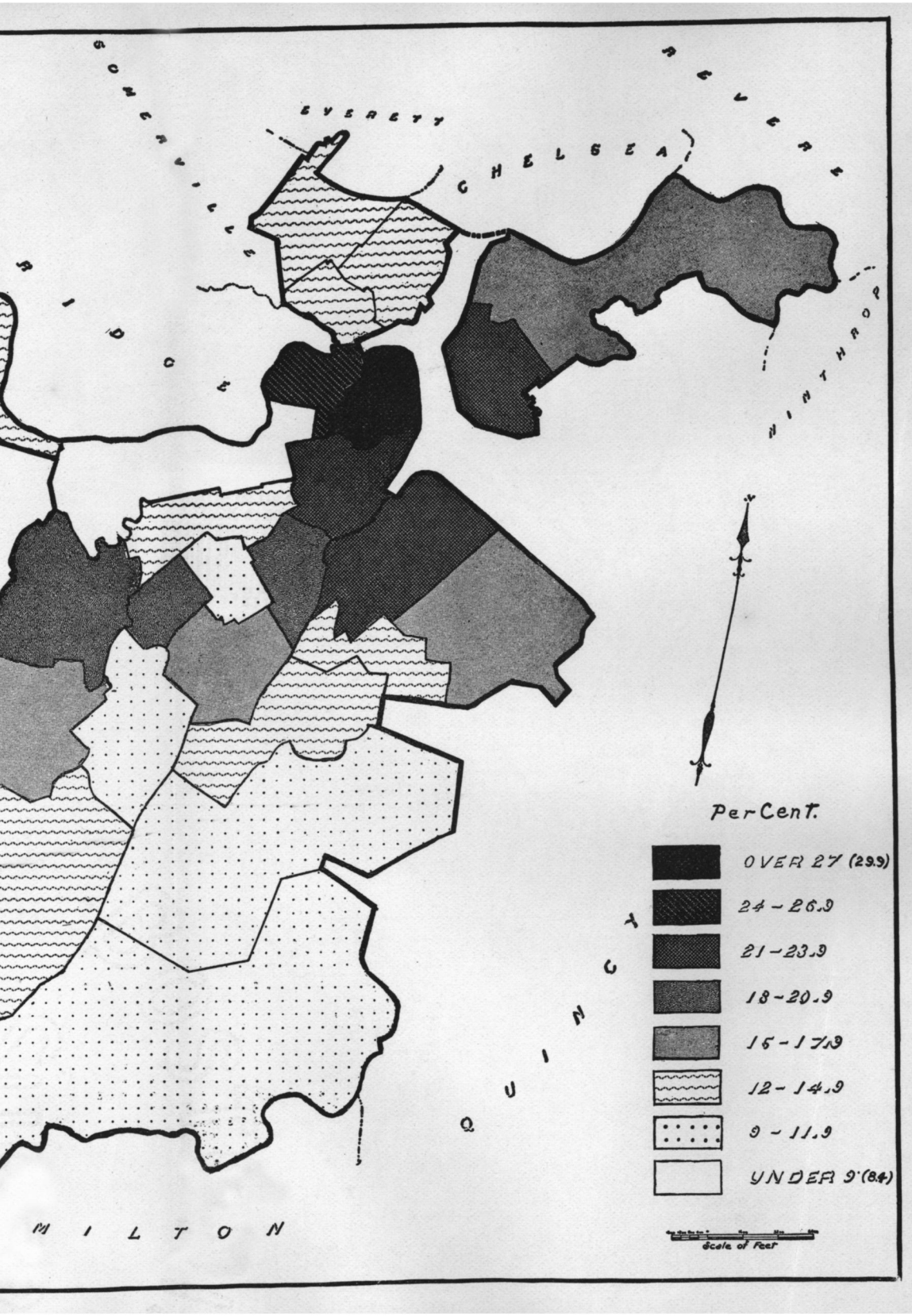
MILTON


SOMERVILLE
EVERETT
CHELSEA
REVERE
MIDDLE
WINTHROP
QUINCY
MILTON
Per Cent.
OVER 27 (29.9)
24 - 26.9
21 - 23.9
18 - 20.9
15 - 17.9
12 - 14.9
9 - 11.9
UNDER 9 (8.4)
Scale of Feet